

What is claimed is:

1. A multiple phase winding for use in electromotive devices using an axial gap structure, comprising:
 - a plurality of individual windings, each of said individual windings corresponding
- 5 to a single phase and having a first face directed in a first axial direction and a second face directed in the opposite axial direction; each of said individual windings also defining a plurality of working length portions, and a plurality of interior and exterior end turn portions;
 - wherein the first face of one of said individual windings crosses over the second
- 10 face of another of said individual windings in the area of at least one of their respective interior and exterior end turn portions, defining a crossover area, and wherein the crossover areas of the first and second faces of said respective individual windings define intermeshing notches, resulting in said multiple phase winding having at least one end turn region with at least a portion of the first face of that one end turn region
- 15 lying in a first plane and comprising portions of all of the first faces of all of the respective end turn portions of all of said individual windings, and at least a portion of the second face of that one end turn region lying in a second plane and comprising portions of all of the second faces of all of the respective end turn portions of all of said individual windings.

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2. A multiple phase winding for use in electromotive devices as recited in claim 1, wherein said first and second faces of said working length portions lie in said first and

second planes.

3. A multiple phase winding for use in electromotive devices as recited in claim 1, wherein said first and second faces of said working length portions taper toward each other to form frustoconical surfaces.
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4. A multiple phase winding for use in electromotive devices as recited in claim 1, wherein said first and second faces of said one end turn region are tapered.
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5. A multiple phase winding for use in electromotive devices as recited in claim 1, wherein each of said individual windings is made up of a plurality of interconnected coil shapes.
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6. A multiple phase winding for use in electromotive devices as recited in claim 1, wherein each of said individual windings has a wave shape.
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7. A multiple phase winding for use in electromotive devices as recited in claim 5, wherein at least one of said individual windings defines notches in both its first and second faces.
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8. A multiple phase winding for use in electromotive devices as recited in claim 6, wherein at least one of said individual windings defines notches in both its first and
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second faces.

9. A multiple phase winding for use in electromotive devices as recited in claim 5, wherein said plurality of interconnected coil shapes forms a ring defining an axis of rotation.

10. A multiple phase winding for use in electromotive devices as recited in claim 5, wherein said plurality of interconnected coil shapes forms a linear arrangement.

10 11. A multiple phase rotary electromotive device, comprising:
a housing, including a first housing portion having a first flange and a second housing portion having a second flange;
a rotor disk located inside said housing and having an axis of rotation;
a multiple phase winding clamped between said first and second flanges and
defining an axial gap between said multiple phase winding and said rotor disk, said
multiple phase winding including a plurality of individual phase windings which cross
over each other, each of said individual phase windings having first and second axially
opposed faces, wherein said first flange contacts the first faces of all of said individual
phase windings, and said second flange contacts the second faces of all of said
individual phase windings.

12. A multiple phase electromotive device as recited in claim 11, and further

comprising a magnet mounted on said rotor disk.

13. A multiple phase electromotive device as recited in claim 12, and further comprising a second rotor disk located inside said housing and having the same axis of rotation as said first rotor disk, said first rotor disk being mounted adjacent the first face of said multiple phase winding, and said second rotor disk being mounted adjacent the second face of said multiple phase winding.

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10 14. A multiple phase electromotive device as recited in claim 13, and further comprising a magnet mounted on said second rotor disk.

15. A multiple phase electromotive device as recited in claim 11, wherein each of said overlapping individual phase windings defines a notch where it overlaps another of said overlapping individual phase windings, forming intermeshing notches.

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16. A multiple phase electromotive device, comprising:
a housing, including a first housing portion having a first flange and a second housing portion having a second flange;
a multiple phase winding clamped between said first and second flanges, said
20 multiple phase winding including a plurality of individual phase windings;
each of said individual phase windings defining first and second opposed faces and having:

a plurality of working length portions each having a first axial height; and
a plurality of inner and outer end turn portions, each of said end turn portions
defining at least one crossover notch having a second axial height, and a bridging
section having a third axial height;

5 wherein said second axial height is less than said first and third axial heights;
and
 wherein said individual phase windings cross each other at their respective
crossover notches; and
 said first flange contacts the first faces of all of said overlapping individual phase
10 windings, and said second flange contacts the second faces of all of said overlapping
individual phase windings.

17. A multiple phase electromotive device as recited in claim 16, wherein said first
axial height is equal to said third axial height.

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18. A multiple phase electromotive device as recited in claim 16, wherein said first
axial height is smaller than said third axial height.

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19. A multiple phase electromotive device as recited in claim 18, wherein said first
axial height decreases as one proceeds radially outwardly along said working length
portions toward said outer end turn portions.

20. A multiple phase winding for use in electromotive devices, comprising:

a plurality of individual windings, each of said individual windings corresponding to a single phase and having a first axial face directed in a first axial direction and a second axial face directed in the opposite axial direction;

5 each of said individual windings having a plurality of working length portions and a plurality of end turn portions interconnecting their respective working length portions; wherein said individual phase windings cross over each other at substantially right angles in their end turn portions, defining crossover portions; and

wherein each of said individual windings has a notch in its respective crossover portion, with each crossover portion including two intermeshing notches of two

10 individual windings; and wherein the first axial faces of all of said individual windings share a first planar portion lying in a first plane, and the second axial faces of all of said individual windings share a second planar portion lying in a second plane.

15 21. A multiple phase winding for use in electromotive devices as recited in claim 20, wherein said first and second axial faces of said working length portions lie in said first and second planes.

22. A multiple phase winding for use in electromotive devices as recited in claim 20,

20 wherein said first and second axial faces of said working length portions lie in third and fourth planes, which are different from said first and second planes.

23. A multiple phase winding for use in electromotive devices as recited in claim 20, wherein said first and second axial faces of said working length portions taper toward each other as they progress in a radial direction to form a frustoconical surface.

5 24. A multiple phase winding for use in electromotive devices, comprising:

 a plurality of ribbon conductors, each of said ribbon conductors having first and second opposed flat conductor faces and first and second edges, with the distance between said first and second edges defining a ribbon height and the distance between said first and second flat conductor faces defining a ribbon thickness that is

10 substantially less than the ribbon height; wherein each of said ribbon conductors includes a plurality of layers, with the flat conductor faces of adjacent layers lying proximate to each other, to form an individual winding corresponding to a single phase;

 each of said individual windings having the same height as its respective ribbon conductor and having first and second opposed winding faces formed by the first and

15 second edges of its respective ribbon conductor, respectively;

 each of said individual windings having a plurality of working length portions and at least one outer end turn portion and one inner end turn portion interconnecting its respective working length portions; wherein said individual phase windings cross each other in at least one of their end turn portions to form crossover portions; and

20 wherein each of said individual windings has a notch in its respective crossover portion, formed by reducing the height of the ribbon conductor layers in the crossover portion of the respective winding, and wherein the notches of two individual windings

are intermeshed.

25. A multiple phase winding for use in electromotive devices as recited in claim 24,
wherein said ribbon height at said working length portions is less than said ribbon
5 height at said outer end turn portions.

26. A multiple phase winding for use in electromotive devices as recited in claim 24,
wherein said ribbon height at said working length portions is the same as the ribbon
height at said outer end turn portions.

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27. A multiple phase winding for use in electromotive devices as recited in claim 25,
wherein said ribbon height at said working length portions decreases as one moves
radially outwardly along said working length portions toward said outer end turn portions
to form a frustoconical surface.

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28. A multiple phase winding for use in electromotive devices as recited in claim 24,
wherein at least one of said individual windings has a plurality of notches along one of
said first and second opposed winding faces, and wherein at least another of said
individual windings has a plurality of notches along both its first and second opposed
20 winding faces.

29. A multiple phase winding for use in electromotive devices as recited in claim 20,

wherein said first and second axial faces of said working length portions lie in third and fourth planes, which are different from said first and second planes, respectively.

30. A method for making a multiple phase winding for an electromotive device,

5 comprising the steps of:

winding a first ribbon conductor having a first height around a mandrel to form a first multi-layered flat loop having the same height as the first ribbon conductor;

winding a second ribbon conductor around a mandrel to form a second multi-layered flat loop having the same height as the first ribbon conductor;

10 cutting notches in said first and second loops;

insulating said notches; and

crossing said loops at their respective notches to form a multiple phase winding having the same height as the first ribbon conductor.

15 31. A method for making a multiple phase winding for an electromotive device as recited in claim 30, and further comprising the step of deforming said first and second loops into a wave shape.

32. A method for making a multiple phase winding for an electromotive device,

20 comprising the steps of:

forming a solid cylindrical blank of a conductor material;

cutting individual conductor turns from said blank, of the required thickness to

produce the number of turns desired in a first phase winding;
cutting at least one notch in said first phase winding;
applying an electrical insulation coating over said first phase winding;
forming a second phase winding by repeating the above steps; and
5 assembling said first and second phase windings with their respective notches
intermeshing.

33. A method for making a multiple phase winding for an electromotive device as
recited in claim 32, wherein said blank has the general shape and cross-sectional
10 profile of the final phase winding.

34. A method for making a multiple phase winding for an electromotive device as
recited in claim 32, and further comprising the steps of deburring and cleaning said
winding prior to applying the electrical insulation coating.

15 35. A method for making a multiple phase winding for an electromotive device as
recited in claim 34, and further comprising the step of potting said phase winding after
cutting the individual conductor turns.

20 36. A multiple phase winding for use in electromotive devices as recited in claim 1,
wherein said first and second faces of said working length portions lie in third and fourth
planes, respectively, which are different from said first and second planes.

37. A multiple phase winding for use in electromotive devices as recited in claim 20, wherein said first and second axial faces of said end turn portions taper toward each other as they progress in a radial direction to form frustoconical surfaces.

5 38. A multiple phase winding for use in electromotive devices as recited in claim 22, wherein said ribbon height at said end turn portions decreases as one moves radially along said end turn portions, away from said working length portions, to form a frustoconical surface.